## NASA/TM-2000-209891, Vol. 188



# Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)

Forrest G. Hall and Andrea Papagno, Editors

## Volume 188 BOREAS TE-23 Map Plot Data

P.M. Rich and R. Fournier

National Aeronautics and Space Administration

**Goddard Space Flight Center** Greenbelt, Maryland 20771

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## **BOREAS TE-23 Map Plot Data**

Paul M. Rich, Richard Fournier

## Summary

The BOREAS TE-23 team collected map plot data in support of its efforts to characterize and interpret information on canopy architecture and understory cover at the BOREAS tower flux sites and selected auxiliary sites from May to August 1994. Mapped plots (typical dimensions 50 m x 60 m) were set up and characterized at all BOREAS forested tower flux and selected auxiliary sites. Detailed measurement of the mapped plots included:

- stand characteristics (location, density, basal area)
- map locations DBH of all trees
- detailed geometric measures of a subset of trees (height, crown dimensions)
- understory cover maps.

The data are stored in tabular ASCII files.

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#### 1. Data Set Overview

#### 1.1 Data Set Identification

BOREAS TE-23 Map Plot Data

#### 1.2 Data Set Introduction

This canopy architecture and understory cover data set provides BOReal Ecosystem-Atmosphere Study (BOREAS) investigators with a common ground-truth site characterization for the major study sites at tree and stand levels, and provides links between the various disciplines involved in BOREAS. Mapped plots (typical dimensions 50 m x 60 m) were set up and characterized at all forested tower flux and selected auxiliary sites.

#### 1.3 Objective/Purpose

These mapped plots serve two general functions:

- To provide comprehensive canopy architecture measurements for a site representative of a specific type of forest.
- To provide a study area for field measurements, such as studies of light regime, leaf area index (LAI), and tree population dynamics.

More specifically, the mapped plots serve as the location for:

- Intercomparison and calibration of techniques used to estimate LAI, fraction of intercepted photosynthetically active radiation (FIPAR), and fraction of absorbed photosynthetically active radiation (FAPAR).
- Testing geometric models concerning radiant transport in canopies.

#### 1.4 Summary of Parameters

- General information about mapped plot: study area, forest type, grid dimensions, direction and distance from flux tower or other georeferenced location, stand density, basal area, average height, average crown radius.
- Measurements for all trees (> 2 m height) in the mapped plot: X-Y location in the local grid coordinate system, diameter at breast (DBH), dominance class (dominant, codominant, suppressed, juvenile, dead standing, dead leaning).
- Measurements for a subset of trees: height, height to base of first branches, height to base of green crown, crown radius in four azimuth directions.
- Understory cover for 10-m x 10-m subplots: hand-drawn maps of major cover classes, description of dominant species and understory features, catalog of photographs.

#### 1.5 Discussion

A total of 13 mapped plots were set up and characterized for 1) the Old Aspen (OA), Old Black Spruce (OBS), Old Jack Pine (OJP), and Young Jack Pine (YJP) tower flux sites in the Southern Study Area (SSA); 2) the OBS, OJP, and YJP tower flux sites in the Northern Study Area (NSA); 3) four locations representing a successional series within a mixed aspen - white spruce site Terrestrial Ecology (TE) tower site in the SSA; and 4) the OA TE tower site and a Young Aspen (YA) auxiliary site in the NSA. Site characterization involved setting up a reference grid, mapping and labeling individual trees, measuring basic crown geometry, and mapping understory cover.

Our site characterization at the tree and canopy levels is part of a hierarchical sampling approach for characterization of canopy architecture (Fournier et al., 1995). This approach involves a series of three sets of scale-tailored measurements spanning from leaf to stand levels: 1) tree vectorization (Landry et al., 1994), involving detailed sampling of the three-dimensional distribution of canopy elements and crown form; 2) site characterization (this data set), involving detailed measurements of individual tree location, crown geometry, and understory cover; and 3) measurement of canopy geometry as seen from beneath, involving acquisition of a multitemporal catalog of hemispherical photographs. The tree vectorization data set has been provided by R. Landry, Canada Centre for Remote Sensing (CCRS). The catalog of hemispherical photographs has been provided to the BOREAS Information System (BORIS) by P.M. Rich, University of Kansas (KU) (TE-23). This text focuses on the description of the measurements taken for the site characterization at the crown and site level.

#### 1.6 Related Data Sets

BOREAS RSS-04 1994 Southern Study Area Jack Pine LAI and FPAR Data

BOREAS RSS-07 LAI, Gap Fraction, and fPAR Data

BOREAS RSS-07 Regional LAI and FPAR Images From Ten-Day AVHRR-LAC Composites

BOREAS RSS-07 Landsat TM Maps of LAI and Fpar

BOREAS RSS-19 1994 CASI At-sensor Radiance and Reflectance Images

BOREAS RSS-19 1996 CASI At-sensor Radiance and Reflectance Images

BOREAS RSS-19 1994 Seasonal Understory Reflectance Data

BOREAS TE-23 Canopy Architecture and Spectral Data from Hemispheric Photography

## 2. Investigator(s)

#### 2.1 Investigator(s) Name and Title

Dr. Paul M. Rich (TE-23) Associate Professor University of Kansas

Dr. Richard A. Fournier (TE-23, RSS-19, and TE-9) Research Scientist Canadian Forest Service

## 2.2 Title of Investigation

Canopy Architecture of Boreal Forests: Using Hemispherical Photography for Study of Radiative Transport and Leaf Area Index

#### 2.3 Contact Information

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## 3. Theory of Measurements

Most measurements involved simple procedures and instrumentation. However, the complete data set is large and required a labor-intensive campaign. The following brief description of all measurements is provided by category for those who are not familiar with standard forestry procedures.

- X-Y locations: Location of the grid was determined based on distance and direction from a known reference location (typically the Tower Flux (TF) or TE tower). Location of each grid marker was determined by measuring distances and directions relative to other grid markers. X-Y grid coordinates of each tree within the mapped plot were determined by triangulation from distance measurements taken from two adjacent grid markers.
- Height measurements: Height was calculated based on measurements of the horizontal distance from the observer to the target, the angle from the observer's eye level to the top of the target, and the angle from the observer's eye level to the base of the target. Height was then calculated as the sum of the tangent of each of the two angles times the horizontal distance
- DBH measurements: DBH was measured directly at 1.3 m ht with a diameter tape, which was marked in units of diameter (pi x circumference).
- Crown radius: Crown radius was calculated by locating points directly beneath the outermost extent of the crown and then calculating the distance to the center of the trunk.
- Dominance class: Dominance class (dominant, codominant, suppressed, juvenile, dead standing, dead leaning) was estimated visually based on influence of surrounding crowns on the crown of interest.
- Understory cover: Understory features were characterized by 1) mapping cover in 10-m by 10-m subplots; 2) calculating cover by dominant plants, lichens, and other features; 3) taking a catalog of 35-mm color photographs of each subplot.

## 4. Equipment

## 4.1 Sensor/Instrument Description

Sonic Rangefinder, model Sonin Combo Pro. Conventional forestry instruments included compasses, clinometers, diameter tapes, and 50-m fiberglass tape measures.

#### 4.1.1 Collection Environment

Measurements were made in ambient outdoor conditions from May to August 1994.

#### 4.1.2 Source/Platform

Measurements were taken from the ground.

#### 4.1.3 Source/Platform Mission Objectives

The ground supported the trees and observers.

#### 4.1.4 Key Variables

- General information about mapped plot: study area, forest type, grid dimensions, direction and distance from flux tower or other georeferenced location, stand density, basal area, average height, average crown radius.
- Measurements for all trees (> 2 m height) in the mapped plot: X-Y location in the local grid coordinate system, DBH, dominance class (dominant, codominant, suppressed, juvenile, dead standing, dead leaning).
- Measurements for a subset of trees: height, height to base of first branches, height to base of green crown, crown radius in four azimuth directions.
- Understory cover for 10-m x 10-m subplots: hand-drawn maps of major cover classes, description of dominant species and understory features, catalog of photographs.

#### 4.1.5 Principles of Operation

Distances, for the reference grid markers and tree X-Y locations, were measured using a sonic rangefinder, model Sonin Combo Pro (Sonin, Inc., Scarsdale, NY). This instrument operates in a dual unit mode, with a master and a target unit. An infrared (IR) signal is sent by the master unit in the direction of the target unit. The IR signal triggers an ultrasound signal (25 KHz) that is sent back from the target unit to the master unit and used for distance calculation. When used in dual unit mode, the rangefinder provides distance measurements with an accuracy of 99.5% for a range from 90 cm to 90 m assuming appropriate environmental conditions. Measurements made with the Sonin are affected by several factors: high levels of noise (e.g., machinery), low or high relative humidity levels (RH < 30 % or > 70 %), altitude or barometric pressure (altitude < -0.1 km or > 0.1 km), and significant wind. In addition, the instrument was designed for operation in the 0 to 30 °C range. Therefore, care was taken to make measurements under favorable conditions.

Other measurements were obtained using conventional forestry instruments: compasses, clinometers, diameter tapes, and 50-m fiberglass tape measures. All azimuth measurements were collected relative to magnetic north. Corrections for magnetic declination were performed, using values published in the BOREAS Experimental Plan (Sellers and Hall, 1994) or calculated using United States Geological Survey (USGS) geomagnetism models for Canada.

Real-world map coordinates were provided by BOREAS staff using a global positioning system (GPS).

## 4.1.6 Sensor/Instrument Measurement Geometry

None given.

#### 4.1.7 Manufacturer of Sensor/Instrument

Sonic Rangefinder Model Sonin Combo Pro Sonin, Inc. Scarsdale, NY

#### 4.2 Calibration

## 4.2.1 Specifications

#### **4.2.1.1 Tolerance**

No calibration was required because of the nature of the instruments used. However, the rangefinder, compasses, and clinometers were tested to assess proper functionality. The sonic rangefinder provided distance values with 99.5% accuracy. More specifically, the manufacturer claims that for a distance of 4.27 m, the reading will be within 3 cm of the real distance. Also, an 18-m distance should be read with less than 10-cm error. The typical distance in the map plots ranged from 1 to 12 m. We tested the rangefinder measurement against tape measure for that range and found that the error was well within the manufacturer's specifications even for cases where branches were obstructing the field of view.

#### 4.2.2 Frequency of Calibration

The instrumentation was calibrated once.

#### 4.2.3 Other Calibration Information

None.

## 5. Data Acquisition Methods

The site characterization involved producing a stand map of individual crown locations and dimensions. Mapped plots, with dimensions of 50 m by 60 m (50 m by 40 m for YJP, and 40 m by 40 m for NSA-YA), were placed in areas representative of the "major canopy stratum," as determined by aerial photographs and verified on the ground. These representative stands were selected for relative homogeneity of species composition, age, and soil drainage characteristics. A grid, consisting of painted stakes placed every 10 m (every 5 m for YJP), was installed to establish the coordinate system for all measurements. Each tree in the mapped plot is labeled with numbered aluminum tags nailed in the trunk at eye level. All measured parameters refer to the tree identification numbers.

Once the reference grid was set up and the trees were labeled, we produced a comprehensive site characterization that consisted of measurements of location, DBH, height, and crown extent for trees within the plot. In addition, we produce a map of understory cover. First, we mapped X-Y positions of all trees relative to the grid coordinate system. Next, we measured the DBH of all trees and categorized every tree crown into a standard forestry dominance category: dominant, codominant, suppressed, juvenile, dead standing, or dead leaning. Then, we established stand-specific allometric relationships that permitted calculation of height and crown radius from DBH, based on a statistically significant sample of tree height and crown extent measurements. Crown extent was estimated by averaging measurements made for four azimuth directions. Where warranted, we recorded an estimate of the terrain topography. Finally, we characterized understory cover by dividing the mapped plot into 10-m by 10-m subplots, hand-drawing maps of cover by main understory features for each subplot, and identifying major plant and lichen species within each cover class. We took a catalog of color photographs, consisting of views of each 10-m by 10-m subplot and characteristic views of the canopy.

## 6. Observations

#### 6.1 Data Notes

All pertinent data are contained in the data files.

#### 6.2 Field Notes

Field notes were recorded in notebooks and data sheets and are available from the Oak Ridge National Laboratory (ORNL).

## 7 Data Description

#### 7.1 Spatial Characteristics

#### 7.1.1 Spatial Coverage

The overall BOREAS project was conducted at a 1,000-km by 1,000-km regional area. The SSA was defined to cover a 130-km by 90-km area, and the NSA was defined to cover a 40-km by 30-km area. Each tower flux site was at the scale of approximately 1 km by 1 km.

In terms of spatial coverage, the 13 mapped plots were located at tower flux sites or auxiliary sites throughout both the SSA and NSA. The SSA and NSA measurement sites and associated North American Datum of 1983 (NAD83) coordinates are:

- NSA-OA, site id T2Q6A, Lat/Long: 55.88691°N, 98.67479°W, Universal Transverse Mercator (UTM) Zone 14, N: 6,193,540.7, E: 520,342.
- NSA-ASP-AUX09, site id W0Y5A, Lat/Long: 56.00339°N, 97.3355°W, UTM Zone 14, N: 6,207,706.6, E: 603,796.6.
- NSA-OBS, site id T3R8T, Lat/Long: 55.88007°N, 98.48139°W, UTM Zone 14, N: 6,192,853.4, E: 532,444.5.

- NSA-OJP, site id T7Q8T, Lat/Long: 55.92842°N, 98.62396°W, UTM Zone 14, N: 6198176.3. E: 523496.2.
- NSA-YJP, site id T8S9T, Lat/Long: 55.89575°N, 98.28706°W, UTM Zone 14, N: 6194706.9 E: 544583.9.
- SSA-9OA, site id C3B7T, Lat/Long: 53.62889°N, 106.19779°W, UTM Zone 13, N: 5,942,899.9 E: 420,790.5.
- SSA-MIX (1,2,3,4), site id D9I1M, Lat/Long: 53.7254°N, 105.20643°W, UTM Zone 13, N: 5,952,989.7 E: 486,379.7.
- SSA-OBS, site id G8I4T, Lat/Long: 53.98717°N, 105.11779°W, UTM Zone 13, N: 5,982,100.5 E: 492,276.5.
- SSA-OJP, site id G2L3T, Lat/Long: 53.91634°N, 104.69203°W, UTM Zone 13, N: 5,974,257.5 E: 520,227.7.
- SSA-YJP, site id F8L6T, Lat/Long: 53.87581°N, 104.64529°W, UTM Zone 13, N: 5,969,762.5 E: 523,320.2.

#### 7.1.2 Spatial Coverage Map

Not available.

#### 7.1.3 Spatial Resolution

In terms of spatial resolution, the mapped plot data were measured across scales ranging from approximately 20 cm to approximately 60 m. Accuracy of tree X-Y maps is generally better than 20-cm resolution. Each mapped plot is typically 50 m by 60 m.

#### 7.1.4 Projection

The plot location is given in reference to the tower site location. The tree location is given in relation to the local reference point (usually the TF or TE tower).

#### 7.1.5 Grid Description

Location of the X-Y grid was determined based on distance and direction from a known reference location (typically the TF or TE tower). The following is a summary of the grid layout:

Site	Location	Width	Grid Interval
SSA-OBS	150 to 230 m (SE)*	+/-20 m	10 m
SSA-OJP	130 to 180 m (SE)	+/-30  m	10 m
SSA-YJP	30 to 80 m (SE)	+/-30  m	10 m
SSA-OA	70 to 120 m (SW)	+/-20 m	10 m
NSA-OBS	80 to 130 m (SE)	+/-30  m	10 m
NSA-OJP	70 to 120 m (SE)	+/-30  m	10 m
NSA-YJP	120 to 150 m (SE)	+/- 20 m	5 m

Location of the grid refers to the distance and direction from the flux tower (reference location) along the optical (Jing Chen's Remote Sensing Science (RSS)-07) transect "B" line (called the center line) in the azimuth direction from North (0°) to the center point of the plot edge closest to the reference location. All transect lines were clearly marked by pink flags, and the sample locations within the mapped plots are marked with stakes (orange wooden stakes in most sites, blue PVC tubes at SSA-OBS). The mapped plot coordinates are marked on the stakes, with the distance from the tower as the x-coordinate and the distance from the centerline as the y-coordinate (except for SSA-OBS, where the x-coordinate of the first mapped location is 0 for consistency with the TE-20/TE-22 mapped plot). SE (135°) or SW (225°) refers to the direction from the tower. Width refers to dimensions of the mapped plot on either side of the optical transect "B" line, except in the case of SSA-OBS, where a "D" line is used, i.e., along the Y=20 line of the grid. Grid interval refers to spacing of grid stakes.

#### 7.2 Temporal Characteristics

#### 7.2.1 Temporal Coverage

The mapped plots were set up and characterized between May and August 1994.

#### 7.2.2 Temporal Coverage Map

The canopy architecture site characterization should generally apply to all of the summer of 1994, because most aspects of a forest stand typically do not change to an appreciable degree during a growing season. For example, changes in DBH and height because of growth would not generally be detected over this time scale. Likewise, modification of stand structure caused by mortality would also not typically be important. No major disturbance (fires, storms, etc.) occurred in any of the mapped plots during the summer of 1994.

#### 7.2.3 Temporal Resolution

Mapped plot characteristics generally apply to all of the summer of 1994, and are thus annual measurements.

#### 7.3 Data Characteristics

#### 7.3.1 Parameter/Variable

The parameters contained in the data files on the CD-ROM are:

#### TE23\_MAP\_PLOT\_SUMMARY

Column Name SITE NAME SUB SITE MEASUREMENT\_YEAR REF UTM EASTING REF\_UTM\_NORTHING UTM ZONE REF DISTANCE REF AZIMUTH DIRECTION PLOT DIMENSION X AXIS PLOT\_DIMENSION\_Y\_AXIS REF X GRID COORD REF Y GRID COORD MIN X GRID COORD MAX\_X\_GRID\_COORD MIN Y GRID COORD MAX\_Y\_GRID\_COORD TREE STEM DENSITY 2M TREE STEM DENSITY 2M 50MM DBH TREE STEM DENSITY 2M 100MM DBH BASAL AREA 2M MEAN DIAMETER BREAST HT SDEV DIAMETER BREAST HT MAX DIAMETER BREAST HT NUM DIAMETER BREAST HT MEAN\_TREE\_HEIGHT SDEV TREE HEIGHT MAX\_TREE\_HEIGHT NUM OBS TREE HEIGHT MEAN CALC TREE HEIGHT

SDEV\_CALC\_TREE\_HEIGHT
MAX\_CALC\_TREE\_HEIGHT
NUM\_OBS\_CALC\_TREE\_HEIGHT
COEFF\_A\_HEIGHT
COEFF\_B\_HEIGHT
COEFF\_C\_HEIGHT
COEFF\_D\_HEIGHT
CRTFCN\_CODE
REVISION DATE

#### TE23\_MAP\_PLOT\_SITE

Column Name

SITE NAME

SUB\_SITE
MEASUREMENT\_YEAR
PLOT\_ID
TREE
SPECIES
UTM\_ZONE
UTM\_EASTING
UTM\_NORTHING

X\_GRID\_COORD

Y\_GRID\_COORD

TREE\_DIAMETER\_BREAST\_HT

DOMINANCE CLASS

TREE HEIGHT

CALC\_TREE\_HEIGHT

LOWEST\_BRANCH\_HEIGHT

LOWEST\_GREEN\_FOLIAGE\_HEIGHT

CROWN\_RADIUS\_NORTH

CROWN\_RADIUS\_SOUTH

CROWN\_RADIUS\_EAST

CROWN\_RADIUS\_WEST

CRTFCN\_CODE

REVISION DATE

#### 7.3.2 Variable Description/Definition

The descriptions of the parameters contained in the data files on the CD-ROM are:

#### ${\tt TE23\_MAP\_PLOT\_SUMMARY}$

Column Name Description \_\_\_\_\_\_ SITE NAME The identifier assigned to the site by BOREAS, in the format SSS-TTT-CCCCC, where SSS identifies the portion of the study area: NSA, SSA, REG, TRN, and TTT identifies the cover type for the site, 999 if unknown, and CCCCC is the identifier for site, exactly what it means will vary with site type. SUB SITE The identifier assigned to the sub-site by BOREAS, in the format GGGGG-IIIII, where GGGGG is the group associated with the sub-site instrument, e.g. HYD06 or STAFF, and IIIII is the

identifier for sub-site, often this will refer to an instrument. MEASUREMENT YEAR The year in which the data were collected. REF\_UTM\_EASTING The UTM easting map coordinate of the reference location, usually the flux tower. REF\_UTM\_NORTHING The UTM northing map coordinate of the reference location, usually the flux tower. UTM\_ZONE The zone on which the given UTM northing and easting coordinates are based. REF DISTANCE The distance from the reference location to the center point of the plot edge closest to the reference location. The azimuth direction from the reference location REF\_AZIMUTH\_DIRECTION to the centerline of the mapped plot. PLOT DIMENSION X AXIS The plot dimension along the X grid axis. PLOT DIMENSION Y AXIS The plot dimension along the Y grid axis. REF\_X\_GRID\_COORD The X grid coordinate that corresponds to the reference location. The Y grid coordinate that corresponds to the REF\_Y\_GRID\_COORD reference location. MIN\_X\_GRID\_COORD The minimum grid X value, which defines an edge of the mapped plot along the X axis. MAX\_X\_GRID\_COORD The maximum grid X value, which defines an edge of the mapped plot along the X axis. The minimum grid Y value, which defines an edge MIN Y GRID COORD of the mapped plot along the Y axis. MAX\_Y\_GRID\_COORD The maximum grid Y value, which defines an edge of the mapped plot along the Y axis. TREE STEM DENSITY 2M The areal density of trees having stems greater than 2 meters tall TREE STEM DENSITY 2M 50MM DBH The areal density of trees having stems greater than 2 meters tall and diameter at breast height of 50 mm or greater. TREE\_STEM\_DENSITY\_2M\_100MM\_DBH The areal density of trees having stems greater than 2 meters tall and diameter at breast height of 100 mm or greater. BASAL\_AREA\_2M The tree stem basal area for all stems greater than 2 meters tall. MEAN\_DIAMETER\_BREAST\_HT The mean diameter at breast height (137 cm above the ground) of the measured trees. SDEV\_DIAMETER\_BREAST\_HT The standard deviation of the diameter at breast height (137 cm above the ground) of the measured MAX DIAMETER BREAST HT The maximum diameter at breast height (137 cm above the ground) of the measured trees. NUM\_DIAMETER\_BREAST\_HT The number of trees for which diameter at breast height was measured. MEAN TREE HEIGHT The mean height of the measured trees. SDEV TREE HEIGHT The standard deviation of the height of the measured trees. MAX TREE HEIGHT The maximum height of the measured trees. NUM\_OBS\_TREE\_HEIGHT The number of trees whose height was measured. MEAN CALC TREE HEIGHT The mean height of the trees calculated from diameter at breast height with allometric

equations

 ${\tt SDEV\_CALC\_TREE\_HEIGHT} \qquad \qquad {\tt The \ standard \ deviation \ of \ the \ calculated \ tree}$ 

height based on diameter at breast height and

allometric equations.

MAX CALC TREE HEIGHT The maximum height of the trees calculated from

diameter at breast height with allometric

equations.

NUM\_OBS\_CALC\_TREE\_HEIGHT The number of trees for which the height of the

trees was calculated from diameter at breast

height with allometric equations.

COEFF\_A\_HEIGHT Stand specific linear regression A coefficient

for calculating the height of the tree using the diameter at breast height (DBH), of the form:

 $tree_ht_calc = ht_coeff_A (hcA)*DBH^3 +$ 

 $(hcB)*DBH^2 + (hcC)*DBH + hcD.$ 

COEFF\_B\_HEIGHT Stand specific linear regression B coefficient

tree\_ht\_calc = ht\_coeff\_A (hcA)\*DBH^3 +

 $(hcB)*DBH^2 + (hcC)*DBH + hcD.$ 

COEFF\_C\_HEIGHT Stand specific linear regression C coefficient

for calculating the height of the tree using the diameter at breast height (DBH), of the form:

tree\_ht\_calc = ht\_coeff\_A (hcA)\*DBH^3 +

 $(hcB)*DBH^2 + (hcC)*DBH + hcD.$ 

COEFF\_D\_HEIGHT Stand specific linear regression D coefficient

for calculating the height of the tree using the diameter at breast height (DBH), of the form:

tree\_ht\_calc = ht\_coeff\_A (hcA)\*DBH^3 +

 $(hcB)*DBH^2 + (hcC)*DBH + hcD.$ 

CRTFCN\_CODE The BOREAS certification level of the data.

Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI

but questionable).

REVISION\_DATE The most recent date when the information in the

referenced data base table record was revised.

TE23\_MAP\_PLOT\_SITE

Column Name Description

SITE\_NAME The identifier assigned to the site by BOREAS,

in the format SSS-TTT-CCCCC, where SSS identifies the portion of the study area: NSA, SSA, REG, TRN, and TTT identifies the cover type for the site, 999 if unknown, and CCCCC is the identifier for site, exactly what it means will vary with

site type.

SUB\_SITE The identifier assigned to the sub-site by

BOREAS, in the format GGGGG-IIIII, where GGGGG is

the group associated with the sub-site

instrument, e.g. HYD06 or STAFF, and IIIII is the identifier for sub-site, often this will refer to

an instrument.

MEASUREMENT\_YEAR The year in which the data were collected.

PLOT\_ID The identifier for the plot from which the

measurement came.

TREE The individual tree from which measurements were

taken.

SPECIES Botanical (Latin) name of the species (Genus

species).

UTM\_ZONE The zone on which the given UTM northing and

easting coordinates are based.

UTM\_EASTING The NAD83 based UTM easting coordinate of the

site.

UTM\_NORTHING The NAD83 based UTM northing coordinate of the

site.

X\_GRID\_COORD The X grid coordinate where the measurements

were taken. Corresponds to the distance from the reference, which was the tower, except at the black spruce site. See documentation for more

details.

Y\_GRID\_COORD The Y grid coordinate where the measurements were

taken. Corresponds to the distance from the reference, which was the tower, except at the black spruce site. See documentation for more

details.

TREE\_DIAMETER\_BREAST\_HT The diameter of the tree at breast height

(137 cm above the ground).

DOMINANCE\_CLASS The dominance class of the tree.

TREE\_HEIGHT The height of the tree.

CALC TREE HEIGHT The height of the tree calculated from the

diameter at breast height, based on allometry.

The height of the lowest branch on the tree

LOWEST\_BRANCH\_HEIGHT The height of the lowest branch on the tree.

LOWEST\_GREEN\_FOLIAGE\_HEIGHT The height of the lowest green foliage on the

tree.

CROWN\_RADIUS\_NORTH

The crown radius on the north side of the crown.

CROWN\_RADIUS\_SOUTH

The crown radius on the south side of the crown.

CROWN\_RADIUS\_EAST

The crown radius on the east side of the crown.

CROWN\_RADIUS\_WEST

The crown radius on the west side of the crown.

CRTFCN CODE

The BOREAS certification level of the data.

Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI

but questionable).

REVISION\_DATE The most recent date when the information in the

referenced data base table record was revised.

#### 7.3.3 Unit of Measurement

The measurement units for the parameters contained in the data files on the CD-ROM are:

#### TE23\_MAP\_PLOT\_SUMMARY

Column Name Units

SITE\_NAME [none]
SUB\_SITE [none]
MEASUREMENT\_YEAR [unitless]
REF\_UTM\_EASTING [meters]
REF\_UTM\_NORTHING [meters]
UTM\_ZONE [unitless]

REF\_AZIMUTH\_DIRECTION [degrees] PLOT DIMENSION X AXIS [meters] PLOT DIMENSION Y AXIS [meters] REF X GRID COORD [meters] REF\_Y\_GRID\_COORD [meters] MIN X GRID COORD [meters] MAX\_X\_GRID\_COORD [meters] MIN Y GRID COORD [meters] MAX Y GRID COORD [meters] TREE\_STEM\_DENSITY\_2M [number of trees][hectare^-1] TREE\_STEM\_DENSITY\_2M\_50MM\_DBH [number of trees][hectare^-1] TREE\_STEM\_DENSITY\_2M\_100MM\_DBH [number of trees][hectare^-1] BASAL\_AREA\_2M [meters^2][hectare^-1] MEAN DIAMETER BREAST HT [meters] SDEV DIAMETER BREAST HT [meters] MAX\_DIAMETER\_BREAST\_HT [meters] NUM DIAMETER BREAST HT [count] MEAN\_TREE\_HEIGHT [meters] SDEV TREE HEIGHT [meters] MAX TREE HEIGHT [meters] NUM\_OBS\_TREE\_HEIGHT [count] MEAN CALC TREE HEIGHT [meters] SDEV\_CALC\_TREE\_HEIGHT [meters] MAX CALC TREE HEIGHT [meters] NUM\_OBS\_CALC\_TREE\_HEIGHT [count] COEFF A HEIGHT [meters][meters^-3] COEFF\_B\_HEIGHT [meters][meters^-2] COEFF C HEIGHT [meters][meters^-1] COEFF D HEIGHT [meters] CRTFCN CODE [none] [DD-MON-YY] REVISION\_DATE

[meters]

#### TE23\_MAP\_PLOT\_SITE

CROWN\_RADIUS\_NORTH

REF DISTANCE

Column Name Units

SITE NAME [none] SUB SITE [none] MEASUREMENT\_YEAR [unitless] PLOT ID [none] TREE [none] SPECIES [none] UTM ZONE [unitless] UTM EASTING [unitless] UTM NORTHING [unitless] X\_GRID\_COORD [meters] Y GRID COORD [meters] TREE DIAMETER BREAST HT [meters] DOMINANCE CLASS [none] TREE\_HEIGHT [meters] CALC\_TREE\_HEIGHT [meters] LOWEST\_BRANCH\_HEIGHT [meters] LOWEST GREEN FOLIAGE HEIGHT [meters]

[meters]

CROWN_RADIUS_SOUTH	[meters]
CROWN_RADIUS_EAST	[meters]
CROWN_RADIUS_WEST	[meters]
CRTFCN_CODE	[none]
REVISION_DATE	[DD-MON-YY]

## 7.3.4 Data Source

The sources of the parameter values contained in the data files on the CD-ROM are:

## TE23\_MAP\_PLOT\_SUMMARY

Column Name	Data Source
SITE_NAME	[BORIS Designation]
SUB_SITE	[BORIS Designation]
MEASUREMENT_YEAR	[Human Observer]
REF_UTM_EASTING	[BORIS Designation]
REF_UTM_NORTHING	[BORIS Designation]
UTM_ZONE	[BORIS Designation]
REF_DISTANCE	[Human Observer]
REF_AZIMUTH_DIRECTION	[Compass]
PLOT_DIMENSION_X_AXIS	[Human Observer]
PLOT_DIMENSION_Y_AXIS	[Human Observer]
REF_X_GRID_COORD	[Human Observer]
REF_Y_GRID_COORD	[Human Observer]
MIN_X_GRID_COORD	[Human Observer]
MAX_X_GRID_COORD	[Human Observer]
MIN_Y_GRID_COORD	[Human Observer]
MAX_Y_GRID_COORD	[Human Observer]
TREE_STEM_DENSITY_2M	[Laboratory Equipment]
TREE_STEM_DENSITY_2M_50MM_DBH	[Laboratory Equipment]
TREE_STEM_DENSITY_2M_100MM_DBH	[Laboratory Equipment]
BASAL_AREA_2M	[Laboratory Equipment]
MEAN_DIAMETER_BREAST_HT	[Laboratory Equipment]
SDEV_DIAMETER_BREAST_HT	[Laboratory Equipment]
MAX_DIAMETER_BREAST_HT	[Laboratory Equipment]
NUM_DIAMETER_BREAST_HT	[Laboratory Equipment]
MEAN_TREE_HEIGHT	[Laboratory Equipment]
SDEV_TREE_HEIGHT	[Laboratory Equipment]
MAX_TREE_HEIGHT	[Laboratory Equipment]
NUM_OBS_TREE_HEIGHT	[Laboratory Equipment]
MEAN_CALC_TREE_HEIGHT	[Laboratory Equipment]
SDEV_CALC_TREE_HEIGHT	[Laboratory Equipment]
MAX_CALC_TREE_HEIGHT	[Laboratory Equipment]
NUM_OBS_CALC_TREE_HEIGHT	[Laboratory Equipment]
COEFF_A_HEIGHT	[Laboratory Equipment]
COEFF_B_HEIGHT	[Laboratory Equipment]
COEFF_C_HEIGHT	[Laboratory Equipment]
COEFF_D_HEIGHT	[Laboratory Equipment]
CRTFCN_CODE	[BORIS Designation]
REVISION_DATE	[BORIS Designation]

## TE23\_MAP\_PLOT\_SITE Column Name

SITE_NAME	[BORIS Designation]
SUB_SITE	[BORIS Designation]
MEASUREMENT_YEAR	[Human Observer]
PLOT_ID	[Human Observer]
TREE	[Human Observer]
SPECIES	[Human Observer]
UTM_ZONE	[BORIS Designation]
UTM_EASTING	[BORIS Designation]
UTM_NORTHING	[BORIS Designation]
X_GRID_COORD	[Human Observer]
Y_GRID_COORD	[Human Observer]
TREE_DIAMETER_BREAST_HT	[Laboratory Equipment]
DOMINANCE_CLASS	[Human Observer]
TREE_HEIGHT	[Laboratory Equipment]
CALC_TREE_HEIGHT	[Laboratory Equipment]
LOWEST_BRANCH_HEIGHT	[Laboratory Equipment]
LOWEST_GREEN_FOLIAGE_HEIGHT	[Laboratory Equipment]
CROWN_RADIUS_NORTH	[Laboratory Equipment]
CROWN_RADIUS_SOUTH	[Laboratory Equipment]
CROWN_RADIUS_EAST	[Laboratory Equipment]
CROWN_RADIUS_WEST	[Laboratory Equipment]
CRTFCN_CODE	[BORIS Designation]
REVISION_DATE	[BORIS Designation]

Data Source

7.3.5 Data Range

The following table gives information about the parameter values found in the data files on the CD-ROM.

#### TE23\_MAP\_PLOT\_SUMMARY

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Data	Below Detect Limit	Data Not Cllctd
SITE NAME	NSA-90A-9TETR	SSA-YJP-FLXTR	None	None	None	None
SUB_SITE	9TE23-MSM01	9TE23-MSM04	None	None	None	None
MEASUREMENT_YEAR	1994	1994	None	None	None	None
REF_UTM_EASTING	420842.9	544479.4	-999	None	None	None
REF_UTM_NORTHING	5942911.1	6198222.7	-999	None	None	None
UTM_ZONE	13	14	None	None	None	None
REF_DISTANCE	0	150	-999	None	None	None
REF_AZIMUTH_ DIRECTION	0	315	-999	None	None	None
PLOT_DIMENSION_X_ AXIS	30	60	None	None	None	None
PLOT_DIMENSION_Y_ AXIS	20	60	None	None	None	None
REF_X_GRID_COORD	0	130	-999	None	None	None
REF_Y_GRID_COORD	0	0	-999	None	None	None
MIN_X_GRID_COORD	-20	130	None	None	None	None
MAX_X_GRID_COORD	20	180	None	None	None	None
MIN_Y_GRID_COORD	-30	0	None	None	None	None

MAX_Y_GRID_COORD	20	40	None	None	None	None
TREE_STEM_DENSITY_2M	1186.7	5543.8	-999	None	None	None
TREE_STEM_DENSITY_	505	4366.7	-999	None	None	None
2M_50MM_DBH						
TREE_STEM_DENSITY_2M	55	1955.6	-999	None	None	None
2M_100MM_DBH						
<del>-</del> -	3.3	41.6	-999	None	None	None
	.041	.206	-999	None	None	None
BREAST_HT						
SDEV_DIAMETER_	.018	.053	-999	None	None	None
BREAST_HT	114	2.4	0.00			
MAX_DIAMETER_BREAST_	.114	.34	-999	None	None	None
HT	0.65	1 4 4 1	0.00		3.7	
NUM_DIAMETER_BREAST_	267	1441	-999	None	None	None
HT	4 1	22.2	000	NT	NT	NT
MEAN_TREE_HEIGHT	4.1	23.2	-999	None	None	None
SDEV_TREE_HEIGHT	1.5	4.5	-999	None	None	None
	7.5 18	33.2 361	-999 -999	None	None	None
MEAN CALC TREE	5.6	22	-999 -999	None	None None	None None
HEIGHT	5.0	22	-999	None	None	None
SDEV CALC TREE	.9	4	-999	None	None	None
HEIGHT	. 9	7	- 9 9 9	NOME	NOTIE	None
MAX_CALC_TREE_HEIGHT	0	28.2	-999	None	None	None
NUM_OBS_CALC_TREE_	267	1441	-999	None	None	None
HEIGHT	207	1111		NOME	NOTIC	NOTIC
COEFF A HEIGHT	-20	1800	-999	None	None	None
COEFF B HEIGHT	-853	-101	-999	None	None	None
COEFF_C_HEIGHT	49.57	198.81	-999	None	None	None
COEFF D HEIGHT	-2.675	7.12517	-999	None	None	None
CRTFCN CODE	CPI	CPI	None	None	None	None
<del>-</del>	09-DEC-98	09-DEC-98	None	None		None
TE23_MAP_PLOT_SITE	3					
	Minimum	Maximum	Missng	Unrel	Below	Data
	Data	Data	Data	Data	Detect	Not
Column Name	Value	Value	Value	Value	Limit	Cllctd
SITE_NAME	NSA-ASP-AUX09	SSA-YJP-FLXTR	None	None	None	None
SUB_SITE	9TE23-MST01	9TE23-MST04	None	None	None	None
MEASUREMENT_YEAR	1994	1994	None	None	None	None
PLOT_ID	N/A	N/A	None	None	None	None
TREE	1	d9	None	None	None	Blank
SPECIES	N/A	N/A	-999	None	None	None
UTM_ZONE	13	14	None	None	None	None
UTM_EASTING	420736.8	603802.3	None	None	None	Blank
UTM_NORTHING	5942809.5	6207805.5	None	None	None	Blank
X_GRID_COORD	-20.27	179.66	-999	None	None	Blank
Y_GRID_COORD	-30.81	44.36	-999	None	None	Blank
TREE_DIAMETER_	.002	.34	-999	None	None	None
BREAST_HT						
DOMINANCE_CLASS	N/A	N/A	-999	None	None	Blank
TREE_HEIGHT	1	33.2	-999	None	None	None

CALC_TREE_HEIGHT	-9	28.2	None	None	None	Blank
LOWEST_BRANCH_HEIGHT	0	16.26	-999	None	None	Blank
LOWEST_GREEN_FOLIAGE_	_ 0	61.2	-999	None	None	Blank
HEIGHT						
CROWN_RADIUS_NORTH	0	4.8	-999	None	None	Blank
CROWN_RADIUS_SOUTH	0	5.5	-999	None	None	Blank
CROWN_RADIUS_EAST	0	4.4	-999	None	None	Blank
CROWN_RADIUS_WEST	0	6.48	-999	None	None	Blank
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	09-DEC-98	09-DEC-98	None	None	None	None
74' ' 77 7	male in the	1 C 1' .	1. 1			

Minimum Data Value -- The minimum value found in the column.

Maximum Data Value -- The maximum value found in the column.

Missng Data Value -- The value that indicates missing data. This is used to indicate that an attempt was made to determine the parameter value, but the attempt was unsuccessful.

Unrel Data Value -- The value that indicates unreliable data. This is used to indicate an attempt was made to determine the parameter value, but the value was deemed to be unreliable by the analysis personnel.

Below Detect Limit -- The value that indicates parameter values below the instruments detection limits. This is used to indicate that an attempt was made to determine the parameter value, but the analysis personnel determined that the parameter value was below the detection limit of the instrumentation.

Data Not Cllctd -- This value indicates that no attempt was made to determine the parameter value. This usually indicates that BORIS combined several similar but not identical data sets into the same data base table but this particular science team did not measure that parameter.

Blank -- Indicates that blank spaces are used to denote that type of value. N/A -- Indicates that the value is not applicable to the respective column.

None -- Indicates that no values of that sort were found in the column.

\_\_\_\_\_

#### 7.4 Sample Data Record

The following are wrapped versions of data record from a sample data file on the CD-ROM.

#### TE23\_MAP\_PLOT\_SUMMARY

SITE\_NAME, SUB\_SITE, MEASUREMENT\_YEAR, REF\_UTM\_EASTING, REF\_UTM\_NORTHING, UTM\_ZONE, REF\_DISTANCE, REF\_AZIMUTH\_DIRECTION, PLOT\_DIMENSION\_X\_AXIS, PLOT\_DIMENSION\_Y\_AXIS, REF\_X\_GRID\_COORD, REF\_Y\_GRID\_COORD, MIN\_X\_GRID\_COORD, MAX\_X\_GRID\_COORD, MIN\_Y\_GRID\_COORD, MAX\_Y\_GRID\_COORD, TREE\_STEM\_DENSITY\_2M,

TREE\_STEM\_DENSITY\_2M\_50MM\_DBH, TREE\_STEM\_DENSITY\_2M\_100MM\_DBH, BASAL\_AREA\_2M, MEAN\_DIAMETER\_BREAST\_HT, SDEV\_DIAMETER\_BREAST\_HT, MAX\_DIAMETER\_BREAST\_HT, NUM\_DIAMETER\_BREAST\_HT, MEAN\_TREE\_HEIGHT, SDEV\_TREE\_HEIGHT, MAX\_TREE\_HEIGHT, NUM\_OBS\_TREE\_HEIGHT, MEAN\_CALC\_TREE\_HEIGHT, SDEV\_CALC\_TREE\_HEIGHT,

MAX\_CALC\_TREE\_HEIGHT, NUM\_OBS\_CALC\_TREE\_HEIGHT, COEFF\_A\_HEIGHT, COEFF\_B\_HEIGHT, COEFF\_C\_HEIGHT, COEFF\_D\_HEIGHT, CRTFCN\_CODE, REVISION\_DATE

'NSA-90A-9TETR', '9TE23-MSM01', 1994, -999.0, -999.0, 14,70,315,50,60,70,0,70,120,-20,40,-999.0,-999

```
'NSA-ASP-AUX09','9TE23-MSM01',1994,-999.0,-999.0,14,0,0,40,40,0,0,-20,20,-20,20,5543.8,2093.8,56.3,11.5,.048,.018,.116,887,6.9,1.6,9.8,25,5.6,.9,9.0,887,-999,-999.0,49.57,3.20909,'CPI',09-DEC-98
```

#### TE23 MAP PLOT SITE

```
SITE_NAME, SUB_SITE, MEASUREMENT_YEAR, PLOT_ID, TREE, SPECIES, UTM_ZONE, UTM_EASTING, UTM_NORTHING, X_GRID_COORD, Y_GRID_COORD, TREE_DIAMETER_BREAST_HT, DOMINANCE_CLASS, TREE_HEIGHT, CALC_TREE_HEIGHT, LOWEST_BRANCH_HEIGHT, LOWEST_GREEN_FOLIAGE_HEIGHT, CROWN_RADIUS_NORTH, CROWN_RADIUS_SOUTH, CROWN_RADIUS_EAST, CROWN_RADIUS_WEST, CRTFCN_CODE, REVISION_DATE

'NSA-ASP-AUX09', '9TE23-MST01', 1994, '2A', '3780', 'Populus tremuloides', 14,603773.3,6207776.5,-999.0,-999.0,04, 'JUVENILE',-999.0,5.19,-999.0,-999.0,-999.0,-999.0,-999.0,
-999.0,-999.0, 'CPI',09-DEC-98

'NSA-ASP-AUX09', '9TE23-MST01',1994, '2A', '3781', 'Populus tremuloides',14,603773.3,6207774.5,-8.7,-11.39,.035, 'SUPPRESSED',-999.0,4.94,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,
```

## 8. Data Organization

#### 8.1 Data Granularity

The smallest unit of data tracked by BORIS was the data collected at a given site on a given date.

#### 8.2 Data Format

The Compact Disk-Read-Only Memory (CD-ROM) files contain American Standard Code for Information Interchange (ASCII) numerical and character fields of varying length separated by commas. The character fields are enclosed with single apostrophe marks. There are no spaces between the fields.

Each data file on the CD-ROM has four header lines of Hyper-Text Markup Language (HTML) code at the top. When viewed with a Web browser, this code displays header information (data set title, location, date, acknowledgments, etc.) and a series of HTML links to associated data files and related data sets. Line 5 of each data file is a list of the column names, and line 6 and following lines contain the actual data.

## 9. Data Manipulations

#### 9.1 Formulae

#### 9.1.1 Derivation Techniques and Algorithms

- Height: height was calculated from DBH based on allometry; for the initial data submission, a linear relationship was satisfactory.
- Summary statistics of DBH, observed height, and calculated height: mean, standard deviation, and maximum were summarized.
- Stand density: stand density was calculated as the total number of trees per unit area (units: individual/ha). The densities of individuals greater than 5 and 10 cm DBH were also summarized (units: individual/ha).
- Stand basal area: stand basal area was calculated as the total area of tree trunks per unit area (units: m²/ha).

• X-Y location: The field measurements consisted of two distances measured from known reference positions along the border of each 10-m by 10-m subquadrant. These two distance values are converted, by triangulation, in X-Y tree locations. The triangulation calculations find the intersection of two arcs. Each arc corresponds to a circle centered at a reference position and with a radius equal to the measured distance from that reference position to the tree. For reference position a,b with an associated distance r and reference position c,d associated with distance q, the X-Y position of the tree can be calculated using the following pair of quadratic equations:

$$x = \frac{-(a^2 - c^2 + b^2 - d^2 + q^2 - r^2)}{2(c - a)}$$
 (1)

$$y = \frac{2b + - [4b^2 - 4(b^2 + (x - a)^2 - r^2)]^{(1/2)}}{2}$$
(2)

Note that these equations give two possible X-Y position solutions. By choosing reference locations along the same edge of a subplot, one solution can readily be rejected as lying outside the subplot.

#### 9.2 Data Processing Sequence

## 9.2.1 Processing Steps

None given.

## 9.2.2 Processing Changes

None given.

#### 9.3 Calculations

## 9.3.1 Special Corrections/Adjustments

None given.

#### 9.3.2 Calculated Variables

See Section 9.1.1.

#### 9.4 Graphs and Plots

None given.

#### 10. Errors

#### 10.1 Sources of Error

Because most of our field instruments were simple and operated with a high degree of accuracy, most error can be attributable to human errors in the field or during data entry. These errors were minimized by careful quality control. The following is a summary of sources of error.

Reference Grid Position: Setting up the grid required use of both distance and azimuth measurements. Though the sonic rangefinder provided distance values that were about 99.5% accurate, small errors result from inexact placement of the master or target units with respect to a plane corresponding to the center of a source or target. Compass readings of azimuth are typically not as precise as distance measurement, because they are sensitive to the presence of metal and local geologic features, and because of inaccuracies in pointing the compass. Field compass measurements are typically not accurate to better than about +/- 4 degrees. Errors were minimized by using distance measurements to check grid reference positions from multiple directions before deciding on the final placement.

- Tree Position: Tree positions were located by measuring distances from known grid locations. Thus, errors could result from inaccuracies in placement of the reference grid. Also, the potential existed for misplacement of a tree because of errors in triangulation calculations. Two positions were calculated for each triangulation. In most cases, one value was outside the subplot, so it could readily discarded. In a few cases, where it was necessary to measure distances from opposite sides of the subplot, it was necessary to determine the correct X-Y location based on the sequence of trees. In a few ambiguous cases, we have eliminated trees from our maps until such time as map positions can be verified in the field. These trees are identifiable in the data set by no-data (-999) values for their X-Y position values.
- Dominance Class: The assignment of the dominance class is somewhat subjective: it depends on the visual assessment of the relative crown height compared with that of the neighboring trees. Through practice and cross-calibrating a selection of dominance classes assigned by different field workers, we were able to minimize this error.
- DBH: Error in measurement of DBH is subject to irregularities in the surface of trunk and variation in placement and tension of the diameter tape. This error was minimized by careful placement of diameter tapes.
- Height: Errors in measurement of tree heights are attributable to the visual ability to align the clinometer with the target location on the tree. Errors were minimized by careful choice of positions for viewing the target tree.
- Crown Radius: Errors in measurement of crown radius result primarily from difficulty in locating points exactly at the outermost extent of foliage. Errors were minimized by training field workers to locate the edge of the crown using a clinometer and by practicing with visual estimates.
- Understory Cover: Mapping of understory cover is subject to errors in drawing of cover category boundaries and in assigning cover categories. Errors were minimized by dividing each 10-m by 10-m subplot into four 5-m by 5-m quadrants for drawing maps. Again, practice and experience of field workers minimized errors.

#### 10.2 Quality Assessment

#### 10.2.1 Data Validation by Source

Much of our quality control involved data validation while still in the field, remeasurement when necessary, and noting of any data problems. Further quality control involved checking for out-of-range values and cross-checking correspondence between data base file values and field data notebooks.

#### 10.2.2 Confidence Level/Accuracy Judgment

Overall, our measurements are well within the accuracy necessary for our studies and for the purposes of other BOREAS researchers. We can readily assign quantitative estimates of accuracy with a high level of confidence.

#### 10.2.3 Measurement Error for Parameters and Variables

The following are quantitative estimates of accuracy of our data. Estimates are based upon a confidence that 95% of values will lie within the specified accuracy range.

#### 10.2.4 Additional Quality Assessments

All data files were checked against original field acquisition sheets.

#### 10.2.5 Data Verification by Data Center

The data were examined for clarity and consistency.

#### 11. Notes

#### 11.1 Limitations of the Data

The mapped plots were selected to be representative of each forest type. Because the forests were relatively homogeneous, the measurements derived from the mapped plots are generally representative of the larger areas. However, caution should be used because of natural variability.

#### 11.2 Known Problems with the Data

The SSA-OBS site was located in an area drier than the forest immediately surrounding the flux tower.

## 11.3 Usage Guidance

As with any data set, caution should be used in the interpretation and application of the data. TE-23 and collaborators have done their best to produce an accurate and useful data set, but do not assume responsibility or liability for the use of the data.

#### 11.4 Other Relevant Information

J.M. Chen's (RSS-07) optical measurements were made on a transect that usually passes through the Y=0 center line of each mapped plot. Also, the catalog of hemispherical photographs acquired by P.M. Rich (TE-23) were taken along the same center line of each mapped plot. Various other groups are expected to supply LAI, FIPAR, and FAPAR data for an intercomparison. Finally, the vectorized trees (i.e., detailed branch segment and needle distribution within crown) measured by R. Landry (RSS-19) were characteristic of trees in the SSA-OJP, SSA-YJP and SSA-OA mapped plots.

All other relevant information is in the data files.

## 12. Application of the Data Set

These mapped plots serve two general categories of applications:

- Modeling applications that require provide comprehensive canopy architecture measurements
  for a site representative of a specific type of forest; e.g., modeling of reflectance patterns,
  modeling of turbulence, modeling of influences of canopy geometry on light regimes, and
  modeling of forest dynamics.
- Field measurement applications that require a mapped study area for field measurements; e.g., field studies of light regime, LAI, and tree population dynamics.

#### 13. Future Modifications and Plans

Further work will involve use of these data, in conjunction with tree vectorization data to characterize the three-dimensional geometry of forests, simulate light regimes, and examine implications for ecology and remote sensing. The understory data need to be more fully developed in data summary files and map coverages before they will be fully useful.

#### 14. Software

#### 14.1 Software Description

Microsoft Excel v.5.x spreadsheets were used for organizing data and performing calculations.

#### 14.2 Software Access

Original Microsoft Excel v.5.x spreadsheets are available upon request from TE-23.

#### 15. Data Access

The map plot data are available from the Earth Observing System Data and Information System (EOSDIS) ORNL Distributed Active Archive Center (DAAC).

#### 15.1 Contact Information

For BOREAS data and documentation please contact:

ORNL DAAC User Services Oak Ridge National Laboratory P.O. Box 2008 MS-6407 Oak Ridge, TN 37831-6407 Phone: (423) 241-3952

Fax: (423) 574-4665

E-mail: ornldaac@ornl.gov or ornl@eos.nasa.gov

#### 15.2 Data Center Identification

Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC) for Biogeochemical Dynamics http://www-eosdis.ornl.gov/.

#### 15.3 Procedures for Obtaining Data

Users may obtain data directly through the ORNL DAAC online search and order system [http://www-eosdis.ornl.gov/] and the anonymous FTP site [ftp://www-eosdis.ornl.gov/data/] or by contacting User Services by electronic mail, telephone, fax, letter, or personal visit using the contact information in Section 15.1.

#### 15.4 Data Center Status/Plans

The ORNL DAAC is the primary source for BOREAS field measurement, image, GIS, and hardcopy data products. The BOREAS CD-ROM and data referenced or listed in inventories on the CD-ROM are available from the ORNL DAAC.

## 16. Output Products and Availability

#### **16.1 Tape Products**

Not applicable.

#### 16.2 Film Products

Not applicable.

#### 16.3 Other Products

The canopy architecture site characterization data set is available in ASCII format and in an ARC/INFO Geographic Information System (GIS) data base format submitted to BORIS and on local UNIX or PC computers at KU and CCRS. Data are also available in Microsoft Excel v.5.0 format from TE-23. These data are available on the BOREAS CD-ROM series.

## 17. References

#### 17.1 Platform/Satellite/Instrument/Data Processing Documentation

Manufacturer's specifications for the sonic rangefinder, model Sonin Combo Pro, Sonin Inc., 672 White Plains Rd., Scarsdale, NY 10583, Tel (914) 725-0202, Fax (914) 725-1158.

## 17.2 Journal Articles and Study Reports

Fournier, R.A., P.M. Rich, Y.R. Alger, V.L. Peterson, R. Landry, and N.M. August. 1995. Canopy architecture of boreal forest: links between remote sensing and ecology. American Society for Photogrammetry and Remote Sensing Technical Papers 2:225-235.

Landry, R., R.A. Fournier, and F.J. Ahern. 1994. Tree Vectorization: a new methodology for characterizing tree architecture in support of remote sensing models. Submitted to Agricultural and Forest Meteorology.

Newcomer, J., D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers, eds. 2000. Collected Data of The Boreal Ecosystem-Atmosphere Study. NASA. CD-ROM.

Sellers, P. and F. Hall. 1994. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1994-3.0, NASA BOREAS Report (EXPLAN 94).

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Sellers, P., F. Hall, and K.F. Huemmrich. 1996. Boreal Ecosystem-Atmosphere Study: 1994 Operations. NASA BOREAS Report (OPS DOC 94).

Sellers, P., F. Hall, and K.F. Huemmrich. 1997. Boreal Ecosystem-Atmosphere Study: 1996 Operations. NASA BOREAS Report (OPS DOC 96).

Sellers, P., F. Hall, H. Margolis, B. Kelly, D. Baldocchi, G. den Hartog, J. Cihlar, M.G. Ryan, B. Goodison, P. Crill, K.J. Ranson, D. Lettenmaier, and D.E. Wickland. 1995. The boreal ecosystem-atmosphere study (BOREAS): an overview and early results from the 1994 field year. Bulletin of the American Meteorological Society. 76(9):1549-1577.

Sellers, P.J., F.G. Hall, R.D. Kelly, A. Black, D. Baldocchi, J. Berry, M. Ryan, K.J. Ranson, P.M. Crill, D.P. Lettenmaier, H. Margolis, J. Cihlar, J. Newcomer, D. Fitzjarrald, P.G. Jarvis, S.T. Gower, D. Halliwell, D. Williams, B. Goodison, D.E. Wickland, and F.E. Guertin. 1997. BOREAS in 1997: Experiment Overview, Scientific Results and Future Directions. Journal of Geophysical Research 102(D24): 28,731-28,770.

# 17.3 Archive/DBMS Usage Documentation None.

## 18. Glossary of Terms

DBH: diameter at breast height (cm).

Stand density: stand density was calculated as the total number of trees per unit area (units: individual/ha).

Stand basal area: stand basal area was calculated as the total area of tree stems per unit area (units:  $m^2/ha$ ).

## 19. List of Acronyms

ASCII - American Standard Code for Information Interchange

BOREAS - BOReal Ecosystem-Atmosphere Study

BORIS - BOREAS Information System

CCRS - Canada Centre for Remote Sensing CD-ROM - Compact Disk-Read Only Memory DAAC - Distributed Active Archive Center

- Diameter at Breast Height DBH EOS - Earth Observing System

EOSDIS - EOS Data and Information System

FAPAR - Fraction of Absorbed Photosynthetically Active Radiation
FIPAR - Fraction of Intercepted Photosynthetically Active Radiation

GEMLab - GIS and Environmental Modeling Laboratory

GIS - Geographic Information System GPS - Global Positioning System GSFC - Goddard Space Flight Center HTML - HyperText Markup Language

IR - Infrared

KU - University of Kansas LAI - Leaf Area Index

NAD83 - North American Datum of 1983

NASA - National Aeronautics and Space Administration

NSA - Northern Study Area
OA - Old Aspen
OBS - Old Black Spruce
OJP - Old Jack Pine

ORNL - Oak Ridge National Laboratory PANP - Prince Albert National Park RSS - Remote Sensing Science

SSA - Southern Study Area

TE - Terrestrial Ecology

TF - Tower Flux

URL - Uniform Resource Locator

USGS - United States Geological Survey UTM - Universal Transverse Mercator

YA - Young Aspen YJP - Young Jack Pine

## 20. Document Information

#### **20.1 Document Revision Date**

Written: 05-Mar-1997 Last Updated: 09-Sep-1999

#### **20.2 Document Review Dates**

BORIS Review: 29-Jan-1999

Science Review:

#### 20.3 Document ID

#### 20.4 Citation

When using these data, please include the following acknowledgment as well as citations of relevant papers in Section 17.2:

#### Simplified Acknowledgment:

The canopy architecture and understory cover data were collected for BOREAS by science team TE-23 under the direction of P.M. Rich at the University of Kansas and R.A. Fournier at the Canadian Forest Service.

#### Acknowledgments -- People:

The canopy architecture and understory cover data were collected for BOREAS under the direction of P.M. Rich at the University of Kansas and R.A. Fournier at the Canadian Forest Service. We thank Y.R. Alger, N.M. August, C. Paquet, and V.L. Peterson for their dedicated efforts in collecting and preparing these data. We also thank J.M. Chen of the Canada Centre for Remote Sensing for his collaboration in plot layout; G. Edwards and H. Margolis of Laval University for their collaboration in data acquisition for the northern sites; M. Apps of Forestry Canada for providing accommodations; and R. Gauthier of the Centre for Remote Sensing for significant scientific, logistical, financial, and moral support.

#### Acknowledgments -- Organizations/Funding Sources:

This work was supported by the Canada Centre for Remote Sensing, Canadian Forest Service, the Kansas Applied Remote Sensing Program, the Kansas Biological Survey, the Kansas Center for Excellence in Computer Aided Software Engineering, NASA grant NAG5-2358, and the University of Kansas Research Development and General Research Funds.

#### If using data from the BOREAS CD-ROM series, also reference the data as:

Rich, P.M. and R.A. Fournier, "Canopy Architecture of Boreal Forests: Using Hemispherical Photography for Study of Radiative Transport and Leaf Area Index." In Collected Data of The Boreal Ecosystem-Atmosphere Study. Eds. J. Newcomer, D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers. CD-ROM. NASA, 2000.

#### Also, cite the BOREAS CD-ROM set as:

Newcomer, J., D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers, eds. Collected Data of The Boreal Ecosystem-Atmosphere Study. NASA. CD-ROM. NASA, 2000.

#### 20.5 Document Curator

#### 20.6 Document URL

## REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE October 2000	3. REPORT TYPE AND DATES COVERED Technical Memorandum		
4. TITLE AND SUBTITLE			5. FUNDING NUMBERS	
Technical Report Series on the Bo	oreal Ecosystem-Atmosphere	e Study (BOREAS)		
BOREAS TE-23 Map Plot Da	ata		923	
C AUTHOR(S)			RTOP: 923-462-33-01	
6. AUTHOR(S) Paul M. Rich and Robert Fou	mai an		111011920 102 00 01	
Forrest G. Hall and Andrea P.	apagno, Editors			
7. PERFORMING ORGANIZATION NAMI	E(S) AND ADDRESS (ES)		8. PEFORMING ORGANIZATION REPORT NUMBER	
Goddard Space Flight Center				
Greenbelt, Maryland 20771			2000-03136-0	
9. SPONSORING / MONITORING AGE	ENCY NAME(S) AND ADDRESS	S (ES)	10. SPONSORING / MONITORING	
			AGENCY REPORT NUMBER	
National Aeronautics and Space	e Administration		TM-2000-209891	
Washington, DC 20546-0001			Vol. 188	
11. SUPPLEMENTARY NOTES				
P.M. Rich: University of Kan	sas Lawrence R Fourni	ier: Canadian Fore	st Service Sainte-Foy	
Quebec; A. Papagno: Raytheo			•	
Quedec, A. Fapagno. Kaymed	JII 1155, IVASA GUUUATU	i space Prigni Cen	ici, Orechoch, maryianu	

#### 12a. DISTRIBUTION / AVAILABILITY STATEMENT

12b. DISTRIBUTION CODE

Unclassified–Unlimited Subject Category: 43

Report available from the NASA Center for AeroSpace Information, 7121 Standard Drive, Hanover, MD 21076-1320. (301) 621-0390.

#### 13. ABSTRACT (Maximum 200 words)

The BOREAS TE-23 team collected map plot data in support of its efforts to characterize and interpret information on canopy architecture and understory cover at the BOREAS tower flux sites and selected auxiliary sites from May to August 1994. Mapped plots (typical dimensions 50 m x 60 m) were set up and characterized at all BOREAS forested tower flux and selected auxiliary sites. Detailed measurement of the mapped plots included:

- stand characteristics (location, density, basal area)
- map locations DBH of all trees
- detailed geometric measures of a subset of trees (height, crown dimensions)
- understory cover maps.

14. SUBJECT TERMS BOREAS, terrestrial ecology, canopy architecture, understory cover.			15. NUMBER OF PAGES 25 16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UL